STAT

Progress in the Mechanization of Construction Work in the USSR

by V. A. Bauman

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PROGRESS IN THE FIELD OF MECHANIZATION OF CONSTRUCTION IN THE USSR

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Construction work in prerevolutionary Russia was conducted, as a rule, without the use of any machinery. Despite the fact that the Russian people created many remarkable machines capable of easing the labor and increasing the productivity of the builders, most of the construction work was done manually.

Even in the most laborious part of construction -- the excavation work -- "mechanization" consisted solely of the wheelbarrow and shovel.

Russia can rightfully be considered the motherland of most of the modern construction machinery and implements.

As attested by the historical "Chronicles," load-lifting devices and machines were used in Russia as early as the Fourteenth and Fifteenth centuries. In 1654, with the aid of hoisting tackle and other devices, the "tsar'-kolokol" (the Imperial Bell), weighing 130 tons, was raised into the belfry of Ivan the Great. In the Eighteenth century, a gifted Russian technician, Kuz'ma Dmitriyevich Frolov, constructed a hydraulic ore-lifting machine and the first industrial specimen of a continuous-action conveyor -- a bucket elevator.

In 1863, a Russian mechanic, Mikhail Konzov, designed and put into operation chain plate conveyors of original design.

Russia was the first country in which machinery was used for excavation work as early as the beginning of the Nineteenth century.

In 1809, a Bukhteyev machine was at work clearing the banks of the Dnepr River. In 1811, an excavating machine was constructed at the Izhorsk Plant for the purpose of clearing the Kronshtadt Harbor. This machine was the prototype of the modern multi-bucket excavator. Steam-operated, single-bucket excavators, for the first time anywhere in the world, were in operation in 1844 — 1848 on the construction of the Nikolayevsk (now October) railroad.

However, all the attempts throughout the prerevolutionary period of the innovators to mechanize construction work and to ease the hard labor of the toilers were purely sporadic. The inertia and stagnation of the Tsarist officials, who had no faith in the creative ability of the Russian people and were filled with admiration for everything foreign, the opposition of the building contractors, who resisted the trend toward substituting expensive machinery for low-cost manual labor, all blocked the way to the wide use of most of the Russian inventions.

Only the Great October Socialist Revolution brought recognition to the creative genius of the gifted Russian people.

Having embarked upon the Socialist industrialization of our Fatherland, the Soviet people, beginning with the first Stalin Five-Year Plan periods, laid the foundations for the rational development of construction machine-building and the mechanization of construction in general.

Twenty years ago, on 23 June 1931, during the session of the Supreme Economic Council in the Kremlin, Comrade Stalin delivered his history-making speech on the subject of "New environment, new tasks for economic development." In it, he pointed out that "Mechanization of labor is the new and decisive force without which it will be impossible to sustain either our rates or our new scales of production."

During the periods of pre-war Five-Year plans, a staggering amount of work was accomplished by the USSR along the line of mechanization of the heavy and laborious industrial processes.

For the mechanization of excavation work, the manufacture of single-bucket excavators, with a bucket capacity of from 0.35 to 2.5 cubic meters, of horse-drawn and tractor-propelled scrapers, of machinery for the hydromechanization of excavation work was mastered. Jaw-, cone-, and roller-rock crushers, beginning with small sizes and working up to such giants as jaw-crushers weighing 220 tons, with jaw dimensions of 1,500 by 2,100 millimeters, and a capacity of 300 cubic meters per hour, for the purpose of mechanizing one of the most tedious types of hard labor -- the preparation of gravel, were put into production. With the manufacture of concrete mixers of varying capacities up to units capable of delivering 1.6 cubic meters of concrete per single mix, the problem of mechanization in the preparation of concrete was solved.

The manufacture of great numbers of other construction and road-building machinery was successfully organized in the Soviet plants.

The mechanization of construction on an even larger scale was being accomplished during the postwar Five-Year Plan.

The tremendous scope of the work of restoration and the new development of the national economy after the Great Fatherland War called for the creation of a broad base for the manufacture of construction and road-building machinery. In 1946, on the initiative of Comrade Stalin, the preliminary steps for the creation of such a foundation were taken.

In the law on the Five-Year Plan for the restoration and development of the USSR national economy during 1946 to 1950, the creation of a specialized base for the production of construction and road-building machinery was designated as one of the most important measures to be undertaken in the field of technical equipment for capital construction.

The law on the Five-Year Plan anticipated the increase in a short time of the manufacture of excavators, the organization and development of production of the newest types of earth-moving, road-building, lifting and transportation, loading and unloading machinery, electrically- and pneumatically-operated construction tools, and also new machinery and equipment for the manufacture of construction materials and parts.

These very important targets at which the Five-Year Plan was aiming were attained ahead of the scheduled time. During the final year of the postwar Five-Year Plan, the mass production of excavators was increased 13 times, of bulldozers — 47 times, of scrapers — more than 8.5 times, of graders — 7 times, self-tripping dump trucks — 12 times, as compared with the year 1940. Altogether, during the postwar Five-Year Plan, the production of 400 types of the latest construction and road-building machines and mechanisms was mastered and organized. Among these, of particular importance are the high-production machines for the mechanization of construction on the vast hydraulic projects in our country.

The ever-growing scope of mechanization and the wide application of new industrial methods radically change the entire aspect of construction. Such building materials as structural solutions and gravel, concrete and concrete parts, which previously were made in semi-skilled methods at the construction site, are now in mass production, and are delivered to the construction site from manufacturing plants. Only such work as by its very nature cannot be transferred into industrial plants for mass production is performed at the construction site. Thus, the work at the construction site is basically reduced to the erection of prefabricated structural assemblies and parts.

The constantly arising problems of mechanization for the construction of projects unmatched and unequalled in scope and in their predetermined rate of completion call for ever new solutions. Some of the great construction projects of Communism are: the Kuybyshev and Stalingrad Hydroelectric Power plants, the South Ukrainian, the North Crimean, the Volga-Don, and the Main Turkmenia canals.

The construction of the greatest hydraulic structures on the Volga, Don, Dnepr, and Amu-Dar'ya rivers is characterized by the stupendous volumes of the earth-moving and concrete-pouring work involved, but principally by the construction rate unequalled anywhere in the world.

It is sufficient to say that "the new power plants alone will deliver annually 22.5 billion kilowatt-hours of low-cost electric power, which is practically equal to the total annual electric power output of Italy." (L. P. Beriya, report at the festive session of the Moscow Soviet on 6 November 1951, in celebration of the 34th anniversary of the Great October Socialist Revolution).

The completion of the greatest construction projects and irrigation systems, with two power houses to be the greatest in the world, and the irrigated area to be practically equal to the total area of Italy, is scheduled to take place during the next six years.

The volume of the earth-moving job which has to be accomplished in the process of erecting the great structures of Communism, attains the staggering figure of 5 billion cubic meters.

It is, therefore, perfectly obvious that a further increase in the degree of mechanization of the work of construction

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is the fundamental condition upon which the erection of these stupendous hydraulic structures and the lowering of construction costs depend.

In conformity with the above, the Government set itself to the task to complete, over the coming 3 to 4 years, the mechanization of the basic construction work by securing the transition from the mechanization of individual processes to the complex mechanization of earth-excavating and moving, loading and unloading of materials, concrete mixing and pouring, reinforced concrete erection, and finishing work, as well as the mechanization of quarries for the breaking and crushing of stone and the preparation of rubble, gravel, and sand.

The overall mechanization anticipates the elimination of manual labor in all types of work and the design of suitable, complete sets of machines to fit the requirements of the job.

At the present time the Soviet structural machine-building industry is well on the way toward creating complex setups of machinery and equipment for plants to manufacture new building materials and parts of prefabricated construction assemblies. It is also well on the way toward creating machines for the complex mechanization of the laborious tasks which still must be tackled at the construction sites.

The laborious jobs which must be undertakin at the construction sites are as follows: excavation and earth-moving, loading and unloading of materials and structural assemblies, erection work, and finish and trim.

Machines for the Mechanization of Earthwork

The earthwork in the construction of industrial plants, housing, and civic projects basically comprises the processing, the transportation, the dumping, and the planning of the earth removal.

For the processing of the earth at these construction projects, single-bucket excavators, with the capacity of the bucket within the range of 0.25 to 2 cubic meters, are used.

The excavator is capable of performing the most diversified types of earthwork by means of special attachments mounted on it.

Thus, the excavator equipped with a forward-stroke shovel rips out the soil above the level of its stand; equipped with a dragline bucket, it digs out great pits below the level of its stand; equipped with a reverse-stroke shovel, it digs holes and trenches; and, finally, when equipped with a clamshell grab bucket, it excavates deep holes and is capable of loading and unloading loose materials.

In place of the excavators of the prewar manufacture, of a design that has become obsolete, the machine-building industry produces at the present time new models equipped with buckets of 0.25, 0.5, and 1.0 cubic meter capacity, and with somewhat modified operational parameters (see Figure 1). An excavator with a 2-cubic-meter bucket is now being designed.

Figure 1. Single-bucket "E-1003" excavator with bucket capacity of 1 cubic meter

In all new excavators with a bucket capacity of 0.5 cubic meters and above, the engagement and disengagement of the hoist clutches and of the brakes is controlled b y means of a hydraulic drive. Shifting the control levers in this case requires only half the effort, as compared to a mechanical control arrangement; this facilitates the work of the operator and raises the efficiency of the machine by approximately 30 percent.

In place of a single-speed traction mechanism for traveling from job to job, as was the case with the old excavators, the new ones, with the exception of those equipped with 1-cubic-meter buckets, are equipped with a two-speed traction mechanism which increases their maneuverability in operation.

The use of alloy steels for making a number of parts in the excavators decreased their total weight, reducing thereby the load on the soil at the caterpillar treads. In the case of the new excavators, the pressure upon the soil at the cater-

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pillar treads is 0.5 to 0.6 kilograms per square centimeter, as compared to 0.8 to 0.85 kilograms per square centimeter for the old-type excavators.

The reduced pressure upon the soil eliminates the sinking of the caterpillar treads and permits the operation of the excavator on less compact soils. With the introduction of a number of improvements in their design, the new excavators of Soviet make are now the best in the world, having left the best foreign makes far behind.

Soviet designers in their creative cooperation with the users and operators of these machines persist in their continuous efforts to improve their designs still further, and at all times they are busy with the creation of new models. One of the innovators in this industry, an excavating specialist named Parkhamchuk, designed and used successfully a bucket of increased capacity on the "Lk -- 05" excavator, completing the annual quota in $2\frac{1}{2}$ months. The example set by Parkhamchuk was eagerly emulated by other excavating specialists in our land.

At the present time, the All-Union Research Institute for Construction and Road-Building Machinery (VNIISTROYDORMASh), engaged in the improvement of excavator design, is conducting experiments with the utilization of hydraulic clutches built on the principle of combined crowding.

Hydraulic clutches, designed to transmit the rotation of the motor shaft to the excavator mechanism via a liquid medium, considerably increase the useful life of the machine by eliminating sudden overloads. The combined crowding, which is characterized by a special operating feature of the cable, provides for more efficient utilization of the engine power, for the operation with a bucket of higher capacity, thereby increasing the productivity of the excavator.

In 1950, the Kalinin Excavator-Building Plant, in effecting the design by Stalin Prize winner Engineer A. S. Rebrov, from VNIISTROYDORMASh, embarked upon the manufacture of pneumatic-tire, truck-mounted excavators, with 0.25 cubic meter buckets, the truck being equipped with four-wheel drive. The rate of travel of these excavators over the roads is 15 kilometers per hour. Because of the rear- and front-wheel drives of the truck on which it is mounted, the excavator can move about with greater ease over roadless terrain, for instance, upon a trackless construction site. Such ease of transportation renders the use of these excavators effective even when the overall volume of earthwork involved in some construction jobs is small.

The mastering of the above type excavator equipped with a 0.5 cubic meter bucket is scheduled for the immediate future. These machines can feed the excavated earth both directly onto dump piles as well as into truckes for hauling to distant dumps. The most effective transportation means for this purpose are sectional conveyors, self-dumping trucks, earth-moving wagons -- all of which are made in our machine-building plants. Sectional conveyors consist in individual sections, 240 meters each. The sections are equipped with a moving conveyor belt, 650 millimeters wide. A transportation line several kilometers long can be assembled from individual sections. The capacity of such a transportation line is 200 cubic meters of earth per hour.

Sectional conveyors are used mostly for the hauling of light- and medium-weight soils which do not contain boulders and heavy clays.

Loading of the soil by the excavator upon the conveyor belt is accomplished through intermediate feeders; these are bins traveling on rails parallel with the conveyor belt -- they have special holes in their bottoms through which the soil is fed evenly to the conveyor belt.

Heavy-weight soils, and the greater part of the medium and light soils, are transported from the excavation sites in self-dumping trucks and earth-moving wagons of special design. There are several types of dump trucks of Soviet make, of which the largest is the "MAZ -- 525" 25-ton self-dumping truck for servicing excavators with 2 to 3 cubic meter bucket capacities. These self-dumping trucks displayed high operating qualities in the hauling of heavy and rock earths during the construction of the Volga-Don Ship Canal. Large-size ballon tires (17 x 32) provide the dump trucks with high roadability. The double-wall steel body of the truck easily sustains the impact of rocks dropped from the excavator bucket, while a steel visor protects the driver at the wheel in the cab of the truck.

Lately, construction projects began to use trailer scrapers with buckets from 1.5 to 6 cubic meters capacity. The scrapers are hitched to "C -- 80," STZ-NATS," and "DT-35" tractors.

The scraper is a giant bucket mounted on a two or four-wheel truck, which is hitched to a tractor. To operate the scraper, it is lowered to the ground, dragged by the tractor, with the scraper blade cutting into the ground and filling the bucket with the earth. The filled scraper bucket is lifted and hauled by the tractor to the dumping pile, where the bucket is emptied.

The lifting and the lowering of the bucket and the dumping of the earth are accomplished with the aid of cables which are controlled by a hoist mounted on the tractor. The advantage of the scraper, as compared to other earthmoving mechanisms is that, in addition to excavating, it also transports, smooths, and partly packs the ground. The most effective use of the scraper is made when the earth is to be hauled for dumping to a distance up to 300 to 400 meters.

For special earthwork such as the excavation of trenches for the laying of sewers and water pipes, several types of automatic, caterpillar-mounted, multi-bucket ditch excavators are built by our plants. The most powerful of these excavators at work in the USSR is one designed for digging a trench 3.5 meters deep. The manufacture of new automotive, caterpillar-mounted, multi-bucket trench excavators is proceeding for the digging of trenches 2.5 meters deep and 1.1 meters wide, i.e., with an operation characteristic corresponding to the most frequently dug trench profile (Figure 2). The production capacity of the "ET-251" trench excavator is 135 cubic meters per hour. The group of designers, headed by Engineer Arvan, who are responsible for this excavator, received the Stalin prize in 1950.

Figure 2. The "ET-251" automotive, caterpillar-mounted, multi-bucket trench excavator.

In 1950, the manufacture of small multi-bucket excavators for the digging of trenches up to 1.2 meters in depth (designed to take subsurface electric and telephone cables) was organized. They were designed for mounting on "STZ-NATI" tractors. At the present time, the building of a series of new multi-bucket trench-digging excavators for the laying of drainage pipes and for other purposes is being mastered.

For the filling of trenches, bulldozers are built for mounting on "STZ-NATI" and S-80" tractors (Figure 3). The working part of the bulldozer is the moldboard with blade located in front of the tractor perpendicular to the axis of the latter. The moldboard is raised or lowered with the aid of control cables or hydraulic cylinders.

Figure 3. "D-157" bulldozer mounted on "S-80" tractor.

With the tractor in motion, the bulldozer blade cuts off a layer of earth, and the moldboard pushes the loosened dirt before it.

The loose earth is pushed by the moldboard without any further help from the bulldozer blade. The use of bulldozers makes for the complete mechanization of trench filling. Bulldozers are also used for the rough-leveling of construction sites and roadbeds. For finish-leveling, motor graders are used successfully. Motor graders are very complex machines. The running gear of the motor grader resembles somewhat the running gear of a heavy automobile, but is equipped with a greater number of transmissions and a number of mechanisms of special design. The working part of the motor grader, as in the case of the bulldozer, is the moldboard with blade. The moldboard is suspended in the central frame between the front and rear axles, and it can be set at various angles both in horizontal and vertical positions. In traveling, the motor grader blade cuts off a layer of earth which is displaced to the sides by the moldboard. The construction of heavy-duty motor graders (Figure 4) was mastered by the Chelyabinsk Plant imeni Kolyushchenko in 1949, and the machine has since become indispensable because of its high efficiency in leveling and grading construction sites and roadbed surfaces.

Figure 4. Heavy-duty "D-144" motor grader

A heavy-duty motor grader is capable of completing from 1.5 to 2 kilometers of a 7-meter wide roadbed in one 8-hour shift.

For construction jobs in which smaller volumes of leveling and grading are involved, smaller motor graders are employed. The building of these smaller machines is now in the process of being mastered. Their engine power is only half that of the heavy-duty grader. The number of driving speeds is also half that of the heavy machine. The greater simplicity of design makes for a lighter and less expensive machine, the use of which will be economical for jobs with low volumes of leveling and grading.

The above-described basic types of machines are only a part of the catalogue of earth-working machinery necessary for the complex mechanization of great construction projects.

In recent years, the Soviet machine-building plants devoted particular attention to the construction of excavating machinery for projects involving tremendous volumes of earthwork such as ship canals, water power installations, etc.

The most remarkable machine for the digging of canals and foundation pits is the giant crawler excavator "ESh-14/65" constructed by the Ural Heavy-Duty Machine-Building Plant (Figure 5). This giant of 1,150 tons is self-propelled. The machine has two alternating movements: the crawler shoes lift and travel, then the excavator itself moves about. The total capacity of the 48 electric motors with which the giant is equipped comprises 5,200 kilowatts. The amount of electric power consumed by the excavator is greater than that consumed by a medium size city.

Figure 5. "ESh-14/65" crawler-mounted excavator with 14 cubic meter bucket

The length of the excavator boom is 65 meters, and the capacity of its bucket is 14 cubic meters of earth, i.e., almost $1\frac{1}{2}$ railway carloads. The bucket is lowered into the pit being excavated and dragged over the bottom toward the excavator, filling with earth in the process. The filled bucket is raised to the front end of the boom, with the boom turning simultaneously to the dumping spot.

The Stakhanov brigades servicing the crawler excavators dig out more than 5,000 cubic meters of earth per shift, replacing the toil of 7,000 to 9,000 laborers. The annual capacity of this excavator is 3 million cubic meters of open earth. These crawler excavators have indeed revolutionized the technology of construction of water installations.

The tremendous working dimensions of these excavators permit, without any additional transfer of loosened soil, the extraction from the earth, in two passes, canals up to 25 meters deep and 150 meters wide along the top.

The group of designers responsible for the "ESh-14/65" excavator, headed by Engineer Saratovskiy, were awarded the Stalin prize.

For the excavation of canals up to 10 meters deep and up to 100 meters wide along the top, the construction of crawler-mounted excavators of smaller size, with bucket capacities of 3.4 and 4 cubic meters and boom lengths of 40 and 37.6 meters, respectively, was mastered by our machine-building industry.

However, in water installations conditions are mostly such as to require the dumping of the loose earth at a distance of 1 to 2 kilometers away. In such instances, the crawler-mounted excavator would have to transfer the earth several times, and its efficiency would be sharply reduced.

Under conditions such as these, the places of the giant crawler excavators are taken by the giant tractor-operated scrapers with capacities of 10 to 15 cubic meters of earth (Figure 6).

Figure 6. Scraper with bucket capacity of 10 cubic meters

The large wheels with pneumatic tires, standing to a height greater than an adult man, make for good roadability on loose soils. Two men servicing the giant scraper with the 15 cubic meter bucket remove and transport 150 to 180 cubic meters of earth per hour, thus performing the labor of 300 men. In the construction of the Volga-Don Ship Canal, the 24-hour production of such scrapers was 2,600 cubic meters each.

In excavations under conditions calling for the transportation of the loose earth to distant dumps, electrically-driven , caterpillar-mounted excavators equipped with 3-cubic-meter buckets are sometimes use. The loose earth is transported to the distant dumps in 25-ton self-dumping trucks.

Finally, in water-construction operations, there is one more very effective method for the extraction and hauling of earth -- the floating, excavating, earth-pumping dredge. The earth-pumping dredge is a ship with pumps mounted on deck, and, controlled from the prow of the ship, is a shaft at the end of which is an implement for cutting and lossening the soil at the bottom of the river. By means of a hoist, the cutting implement is lowered to the bottom of the river, and a rotating motion imparted to it. The soil, partly dissolved in the water and forming a sludge, is sucked in by the pumps and carried through pipelines onto the shore to a distance up to 4 kilometers to be discharged. The dredge, excavating the soil at the bottom of the river in front of itself, moves forward, with the deepened channel behind it. It is clear that this method of excavating ship canals can be used only in direct prosimity to rivers, which continuously replenish the water pumped out by the dredge pumps together with the sludge.

Three types of floating dredges are built for operation on water construction projects. The largest of them weighs 1,100 tons and is equipped with electric motors witha total capacity of 4,800 kilowatts. Sucha dredge can pump out from the river bottom 10,000 cubic meters of sludge containing 1,200 cubic meters of earth, and deliver it trhough pipelines to a distance of 4 kilometers, thereby replacing the labor of 15,000 men. It is one of the most effective methods of soil excavation. 550 cubic meters of soil are extracted and dumped for each man of the dredge-operating crew per working shift.

The group of designers responsible for the construction of the "500" floating dredge, headed by Engineer B. M. Shkundin, received the Stalin prize.

For the leveling of canal banks, the machine-building industry, after having attained the "know-how", is building a multi-bucket transverse scoop excavator (Figure 7), which moves on rails along the shore of the canal in process of construction and shears the soil from the banks, shaping the latter to the required profile. This excavator, equipped with 30-liter buckets, has a capacity of 45 cubic meters per hour and is capable of leveling the banks both below and above the track level. The maximum scooping depth and height is 8.5 meters. The excavator conveyor, upon which the earth is dumped from the buckets, carries the earth for a distance of 20 meters from the operating axis, and to a height up to 10 meters.

Figure 7. The EM-301" multi-bucket transverse scoop excavator

Tremendous progress has been made not only in the creation of new types of excavating and earth-moving machinery and equipment, but also in the efficient utilization of the equipment and the continuous rise in the level of mechanization. The mean output of excavators engaged in construction work has increased 83 percent from 1946 to 1950. The overall level of mechanization of earthwork in 1949 was 1.4 times higher than in 1940, thereby attaining a value of 70.2 percent. On the great construction projects of Communism, the degree of mechanization of earthwork is still higher, attaining a value of 97 to 98 perdent.

Machines for the Mechanization of Pile Driving

A considerable number of industrial, civic, and housing projects, and particularly various engineering structures such as bridges, dams, etc, are erected on pile foundations. In relation to the nature of the soil and the characteristics of the structures to be erected, piles of different weights and materials (wood, concrete, steel), driven to varying depths, are used.

In large-scale water installations, sheet-piling barriers and metal-plank, groove-and-tongue bulkheads of section-shaped profile are used.

The driving of piles and of groove-and-tongue bulkheading is effected with the aid of steam hammers. The Soviet industry makes two types of these hammers — single- and double-action hammers.

At the present time, the know-how for the manufacturing of two models of a newly-designed steam-operated double-action pile driving hammer — with differential steam distribution — for the driving of heavy piles weighing from 4.5 to 10 tons each, is being mastered.

The total weight of the heavier hammer is 8,500 kilograms, and the weight of its impact parts is 3,500 kilograms. The hammer delivers 110 impacts per minute.

A special steam-operated single-action hammer for the driving of reinforced concrete-filler piles is in production. The technique of driving concrete-filler piles is as follows: a steel pipe, 325 to 475 millimeters in diameter, with a solid tip at its bottome end, is driven into the soil. Then, reinforcing steel rods are lowered into the pipe, and concrete is poured in until the pipe is filled. Immediately after the concrete is poured, the steel pipe is removed from the ground, leaving the formed reinforced concrete pile with its bottom metal tip in the ground. The pipe is extracted with the aid of a hoist by connecting the hammer into the hoist circuit for the lifting operation, which is facilitated by the hammer causing the pipe to vibrate and follow it in the lift. Reinforced concrete-filler piles were used in the erection of one of Moscow's skyscrapers.

The Soviet machine-building industry began to master the know-how of a new type of pile driver -- the Diesel-hammer -- as far back as the years of the Great Fatherland War.

The Diesel-hammer is a cylinder with a piston. The cylinder is slipped over the pile, Diesel oil injected into the cylinder through a specially-designed distribution system. The piston rises and falls with the explosions, striking the pile at a frequency of 50 to 60 impacts per minute.

Three types of Diesel-hammers are built at the present time, with weights of the impact piston being 600, 1200, and 1,800 kilograms, respectively. The first hammer, with a total weight of 1,250 kilograms, is designed for the driving of light wooden piles of 20 to 30 centimeters in diameter to a depth of 6 meters. The second hammer, with a total weight of 2,700 kilograms, is used for driving piles weighing up to one tone, and the third hammer, with a total weight of 3,700 kilograms, is used for driving steel and reinforced-concrete piles weighing up to three tons.

As compared to steam hammers, Diesel-hammers are of lighter weight, do not require for their operation any cumbersome steam-generating equipment, and they are always ready for work; all of these factors contribute to their higher efficiency.

Soviet industry makes all the necessary complementary equipment for the steam-operated and Diesel-operated hammers as follows: head frames for the suspension of steam-operated and Diesel-operated hammers and for fixing the direction in which the piles are to be driven; hoists, electric and steam, which lift the impact head of the hammer, and drag and lift the piles; steam boilers and compressors for supplying steam and compressed air to the hammers.

The most recent development in the field of pile driving is the vibrator pile driver, as designed by Barkan and Tripikov, and used for the first time in the construction of the Volga-Don

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Ship Canal. The vibrator sinker is an electric vibrator of special design, weighing 1,350 kilograms. It is braced on the cap of a pile. A 29-kilowatt electric motor, built into the frame of the vibrator, rotates the vibrator shafts to develop a force of 15.8 tons pressing down upon the pile. Since the vibrator shafts rotate at 2,300 revolutions per minute, the load upon the pile is a pulsating load, which accelerated the sinking of the pile.

Sheet piling is driven to a depth of 10 to 12 meters in 2 to 3 minutes, and the cost of driving is about $2\frac{1}{2}$ times less than driving with a double-action steam-operated hammer.

In the case of large water installations, where the number of pile barriers is measured in kilometers, the use of the vibrator pile driver is most effective.

The group of workers headed by Professor Barkan, and responsible for the design of the vibrator, received the Stalin prize.

At the present time, great efforts are being made to arrive at the design of new types of vibrator pile drivers for driving heavy piles in both non-tenacious (sand, gravel) and tenacious (clayey) soils.

Lifting and Transportation, Loading and Unloading Machinery

Lifting and transportation, loadimg and unloading machinery

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occupy an important place at the construction site. Various mechanisms accomplish the lifting of various structural materials to the scaffolding of buildings in the process of construction and the transport of material along the entire stretch of operations within the range of the construction site.

Lately, lifting derrick-cranes, which accomplish both the lifting and the distribution of the loads, have almost completely replaced all devices for horizontal transport (carts, conveyors, wheelbarrows, etc.

In many cases, there is a complete absence of storage facilities at the construction site. The derricks lift the loads from the incoming trucks and hand them over to the work location.

The basic types of lifting and erection derrick-cranes are tower derric-cranes that move on rails along the building being erected. They are made in two types: for buildings up to 4 stories high and for buildings up to 7 stories high. Their lifiting capacity at the maximum boom length of 20 meters is 1.0 to 1.5 tons. At shorter boom length, the lifting capacity of these derricks can be doubled.

In 1950, the VNITO of construction workers announced a competition for the best design of a derrick-crane for use in construction of low buildings. Many designes, particularly for tower derrick-cranes, were submitted; for the best of these prizes were awarded.

Along with tower derrick-cranes, the pneumatic tire-mounted crane excavator (Figure 8) with a lifting capacity of 5 tons is used successfully in construction of low buildings. This derrick-crane is equipped with a boom 18 meters long, built up from sections 2 or 5 meters each.

With the development of the construction of taller buildings, up to 14 stories, and skyscrapers, portable derrick-cranes came into wide use (Figure 9). They are braced to the metal frame of the building undergoing construction, and, upon the completion of 1 to 2 stories, they are raised 1 to 2 stories, and so on. The raising of these derricks is accomplished in the following manner: first, the bull wheel, which fits freely over the bottom of the vertical mast, is raised and braced to the steel framework of the building; then, with the aid of hoisting tackle, which is fastened on the one side to the bull wheel and on the other side to the bottom of the mast, the entire derrick is raised; then the derrick mast is braced to the steel frame of the building and the derrick is set for operation.

Figure 9. Portable derric-cranes at work in the erection of a skyscraper

Figure 8. Crane-excavator "E-255", with a lifting capacity of 5 tons, mounted on pneumatic tires

All the skyscrapers in Moscow are erected with the aid of these portable derrick-cranes. These portable derric-cranes are capable of swinging in a complete circle, and, with their boom length from 22 to 27.5 meters, their lifting capacity is from 3 to 15 tons.

The largest of these portable cranes is operating on the construction of the Moscow State University. Its lifting capacity, at a boom length of 36.8 meters, is 15 tons, and its rate of load lifting is 20 meters per minute.

For the erection of buildings from 8 to 14 stories high, these derrick-cranes are too heavy. Therefore, derricks with lifting capacities of 1.5 tons at a boom length of 22 meters, and an accelerated rate of load lifting, attaining 45 meters per minute, are built; these weigh no more than 11 tons.

The USSR occupies the first place in the design and utilization of derric-cranes used in skyscraper construction.

It must be noted, however, that regardless of the great variety of erection derrick-cranes being manufactured, the problem of mechanization in the assembling of prefabricated housing projects has not yet been solved satisfactorily.

At the present time, various organizations are engaged in the design and building of new derrick-cranes for the erection of prefabricated housimg assemblies.

The new model derrick-cranes are being designed for travel over the ground (modeled after tower derricks) or for travel over the structural frame of the building being erected.

The testing of new models is expected to bring out the most rational design of derrick-cranes for the erection of prefabricated housing assemblies.

The experience in the construction of multi-story buildings and skyscrapers emphasizes the fact that the rates of construction cannot be sustained through theuse of derrick-cranes alone. For the lifting of such materials as structural blocks, solutions, etc, structural elevators must be erected. Since, in the presence of greater distances of lift, the existing types of elevators are inadequate, the machine-building industry is engaged in the design of elevators with a greater rate of lift, and with automatic starting and stopping control.

The use of large assemblies in both industrial and civilian construction call for cranes of ever greater lifting capacity. To satisfy this demand, the plants under the jurisdiction of the Ministry of Construction and Road-Building Machinery devoted the year 1950 to mastering the know-how concerned with the production of rotary tower-and-boom cranes with lifting capacities of 15 and 25 tons.

The crane with a lifting capacity of 15 tons is equipped with a boom 40 meters long and a mast 46 meters high. The crane with the 25-ton lift is equipped with a boom 32 meters long and

and a mast 39 meters high. The work of these cranes is made up of the following operations: the lifting of the load, the raising of the boom, the closing and the opening of the grab bucket, and, finally, the turning of the crane. All these operations are performed by a triple-drum hoist of special design equipped with a slewing attachment. The hoist levers are pneumatically controlled.

Truck-mounted and railcar-mounted cranes are also used for erection work and for loading purposes. At the present time our plants are making several types of these cranes. Full-swing automotive cranes are mounted on the chassis of the ZIS-150 and YaAZ-200 automobiles. The lifting capacity of the first is 3 tons at a boom length of 2.5 meters. The lifting capacity of the second is 5 tons at a boom length of 3.8 meters. The crane mounted on the YaAz-200 automobile chassis is equipped with a boom 7.5 or 12 meters long.

In 1950, the production of 10-ton cranes, mounted on wheels equipped with pneumatic tires (Figure 10), began. These cranes were equipped with booms 10 and 18 meters long, and were capable of traveling at 6 kilometers per hour.

Figure 10. "K-102" lifting crane, capacity 10 tons, mounted on pneumatic-tire wheels

Two types of railroad cranes with lifting capacities of 10 and 25 tons are being built. They are capable of full swing and are self-propelled. The firt type operates at boom lengths of 10 and 18 meters, the second type at boom lengths of 15 and 25 meters. They travel at a speed of 5 to 25 kilometers per hour.

In order to increase the operating output and improve the efficiency of the cranes, a number of lifting container designs for the handling of bricks, blocks, solutions, etc were introduced. The use of the proper containers reduces the lifting time of materials and completely eliminates the setting of the materials on their routes from the manufacturing plants to their proper setup at the construction site. Honorable mention is due to the excellent work in the design of lifting crane containers by two Stakhanovites, F. I. Mal'tsev and I. P. Shirokov.

Special loaders, the construction of which was mastered after the Great Fatherland War, have come into widespread use. Self-propelled, caterpillar-mounted, multi-bucket loaders are used for the transfer of fluid materials into transportation carriers. The fluid material is scraped up toward the bucket elevator with the aid of a multiblade shaft, is picked up by the elevator buckets, lifted, and poured through a chute into the carrier. The capacity of this loader is 110 cubic meters per hour.

Another type of loader for free-flowing materials is a single-bucket, tractor-mounted loader with a lifting capacity of 4 tons (Figure 11). It is designed for mounting on the "S-80" tractor. The 4.5 -cubic-meter bucket is filled while the tractor is in motion. The filled bucket is raised somewhat, the tractor moves on toward a waiting dump truck, the bucket is tipped over across the tractor and unloaded. The capacity of the tractor loader depends on the distance it has to travel from the place of picking up the load to the waiting dump trucks where it is unloaded. If this distance is 10 meters, the loader is capable of discharging 50 bucketloads per hour, which amounts to 200 tons of material. The designers were awarded the Stalin prize.

Figure 11. "T-107" single-bucket tractor loader mounted on an "S-80" tractor, with a bucket capacity of 4.5 cubic meters

For the loading and stacking of unit materials, the industry mastered and is now making fork-lift trucks with lifting capacities of 3 and 5 tons. These loaders, equipped with hydraulic power drives, are capable of lifting the load to a height of 4 meters at the rate of 8.5 meters per minute and of traveling at the rate of 40 kilometers per hour. Their small wheel base and small turning radius (3.6 to 4.0 meters) provide for the high maneuverability of the loader.

Machinery for Mixing and Pouring Concrete

Concrete is the building material of the widest use in all types of modern construction.

The practice of mixing concrete at the immediate construction site resulted in cluttering up the sites with temporary concrete-mixing structures as well as with storage facilities for all sorts of material. These conditions were instrumental in raising the cost without at the same time profiding for the high qualtiy of concrete.

At the present time, only small-scale concrete work is done with the aid of portable concrete mixers of 250-liter drum capacity. In large-scale concrete work, the concrete is delivered to the construction site from special concrete-mixing plants. It is planned that within the next several years all cities will have such concrete plants in operation, with ready-to-use concrete being sold and delivered to the construction projetct.

The concrete will be delivered from the plants in dump trucks when the distances involved are small, or in special trucks equipped for preventing the concrete from hardening when the delivery distances involved are in excess of 5 kilometers.

The plants of the Ministry of Construction and Road-Building Machinery mastered the techniques of the basic equipment necessary for the production of ready-to-use concrete -- the giant concrete mixers with drum capacities of 1,200 and 2,400 liters, and even mixers up to capacities of 4,500 liters, with auxiliary equipment consisting of automatic and semiautomatic proportioning hoppers and weighing devices.

The production of truck-mounted concrete mixers based on the chassis of the "YaAz-200" and "ZIS-150" trucks was mastered in 1950. The precision-proportioned dry ingredients of concrete are loaded into the drums of these mixers, water from proportioning tanks is fed into the drums, and the mixing takes place in the revolving drums while the units are on the way to the construction sites. The concrete arrives fresh (unhardened) at the construction site and is poured with the rotation of the drums reversed.

Concrete to be poured for water-construction installations must be mixed to more exacting specifications: it must be durable, waterproof, and be amenable to convenient pouring into the structural forms, etc. Hence, the composition of this concrete is to be thoroughly selected from several types of gravel and sand; the proportioning of its components is to be maintained to a precision of 2 percent for the gravel and sand, to a precision of 1.5 percent for the cement, and to a precision of 1 percent for the water.

The concrete which is made at the newly mechanized assembly-and-separation concrete-manufacturing plants of great capacities, fully complies with these technical requirements.

Each such plant consists of two buildings with a total volume of 5,700 cubic meters and a height of 32 meters -- practically a 10-story building. The bins for the gravel, sand, and cement are located in the upper story of each building.

The weighing and proportioning apparatuses, which weigh and proportion the materials comprising each mix, are located directly beneath the bins. The weighed materials drop through a rotary chute, in sequence, into one of the four concrete-mixers located in the second story. Each such mixer receives 2,400 liters of concrete ingredients, and, after mixing, delivers 1.7 cubic meters of ready-to-use concrete.

The ready-to-use concrete is unloaded from all four mixers into a general hopper, from which it is delivered by a belt conveyor into containers, and transported to the construction site.

All processes in the concrete-mixing plant, beginning with the delivery of the initial materials from storage into the bins and ending with the discharge of concrete from the mixers, are completely mechanized.

Automatic devices control the precision-timed feeding of the materials into the distribution bins, as well as the precision-proportioning, the exact timing of the mixes. Automatic devices also control the discharge of the mixed concrete into the receiving hopper for distribution into the carriers hauling it to the various construction sites.

If the operational cycle is for some reason interrupted at a certain phase, a corresponding electric signal bulb lights up at the control panel. When, due to an unfavorable mishap, the specified quality of the concrete is threatened, the entire plant mechanism is automatically stopped.

Such a twin plant, with its 8 giant concrete mixers, produces more than 5,000 cubic meters of concrete per 24 hours.

The group of workers under the supervision of V. T. Fedorov, responsible for the design of this automatic concrete-mixing plant, received the Stalin prize in 1951.

The hauling of the ready-to-use concrete to the construction sites is done in special containers by automotive truck or railroad freight cars.

Where no railway or highway gives access to the construction site, the delivery of concrete is accomplished by concrete pumps (Figure 12), the pipelines for which can be laid in otherwise inaccessible places.

Figure 12. The "S-252" concrete pump for delivering concrete through pipelines

The concrete is discharged into the concrete pump receiving hopper either directly from the mixer or from self-dumping trucks.

The receiving hopper is equipped with a mixing apparatus so that the concrete remains fresh (unlaminated). From the hopper, the concrete is sucked into the pump cylinder, from where it is ejected by the piston into the pipeline leading to the construction site. The pump can handle concrete containing stones up to 80 millimeters in size. The inner pump cylinder sleeve and the pump valves are made of wear-resistant materials, and do not require frequent replacement.

The concrete pump is capable of moving the concrete through the pipeline for a horizontal distance of 240 meters, or to a height of 40 meters. It pumps 20 cubic meters of concrete per hour.

These pumps have operated successfully in the construction of skyscrapers in Moscow and of the Volga-Don Ship Canal.

Concrete pumps of a still higher capacity, up to 40 and 80 cubic meters per hour, are being built at present.

The concrete which is fed to the location and poured into place must be compacted and leveled so as to eliminate the possibility of holes and air pockets forming.

Prior to the appearance on the scene of concrete vibrators, the compacting of the poured concrete was done by laborers stamping it with their feet. This process was mechanized by the introduction of concrete vibrators. Performing small oscillations (1 to 2 millimeters) at a frequency of 6,000 per minute, the vibrator liquifies the concrete, promoting its flow into all the pockets. As soon as the vibrators come to a stop, the concrete begins to thicken. The first vibrators used had a very low capacity -- not above 5 cubic meters of concrete per hour.

The ever-growing scale of concrete pouring for water construction installations called for vibrators of much greater capacity. Such vibrators were designed. They are combination batteries of 8 and 16 typical unit vibrators (Figure 13), which are dropped by a crane onto the mass of freshly-poured concrete, which they level out within one minute.

Figure 13. Vibrator battery for concrete leveling

The capacity of such vibrator batteries is 20 to 30 cubic meters of concrete per hour.

For better compacting, the concrete is subjected to vacuuming. The Leningrad Construction Machinery Plant began the mass production of portable concrete-vacuuming installations, which are air pumps mounted on truck wheels. With the air pumps comes a set of shields covering an area of 1 square meter each. The deaeration and water-rmoval is accomplished through shields laid out flat on the concrete surface. These vacuum installations are designed for the simultaneous vacuuming of 20 square meters of concrete surface with a vacuum capacity of 600 millimeters of mercury. With the depth penetration of 10 centimeters, the capacity of the installation is 150 square meters of concrete surface per hour, and with the depth of penetration at 20 centimeters, its capacity is 50 square meters of concrete surface per hour.

Machines for the Mechanization of Finishing Work

Although the finishing jobs in construction are the most laborious and their importance is considerable, they remained unmechanized for a longer period than other construction jobs. Such a lag is basically due to the fact that the finishing jobs must be done on the premises; this eliminates the possibility of applying industrial production methods and makes the design of adequately effective and economical machines for this purpose difficult, not to mention the fact that the machine-building industry is primarily occupied with such basic problems of construction as earthwork, the loading and unloading of structural materials, and the like.

At the present time, however, the Soviet builders, daringly breaking all precedents in structural technology, are arriving at ever-new progressive solutions in the industrialization of construction finishing work.

The use of dry plaster eliminates the necessity for the preparation of plastering solutions, leaving only the installation of prefabricated dry plasterboard. The use of asbestos-cement plates for the facing of the walls of sanitary assemblies simplifies the wall-facing problem considerably.

The most laborious finishing work is the work of plastering, which involves the manufacturing of plastering solutions, their transportation to the construction site, applying the solutions onto the wall surfaces, and the actual plastering operation.

For the preparation of the solution and its delivery to the respective floors of the building being constructed, the following set of equipment is built (Figure 14): a solution mixer, a compressor, a solution pump, rubber hose and nozzle. The production of the so-called plastering solution assemblies have been standardized for a capacity of 2 to 3 cubic meters per hour. These standard assemblies consist of a solution mixer with a capacity of 150 liters, a solution pump capable of delivering 3 cubic meters of solution per hour, and a set of auxiliary equipment for feeding the sand and lime mix. Such standard plastering solution assemblies are delivered to the construction site together with the structural steel, and are mounted on the first floor of the building being erected.

Figure 14. Equipment assemply for the preparation and delivery of the plastering solution: 1 --solution mixer; 2 -- compres-

Figure 14 (cont'd) --- sor pump; 3 --- solution pump; 4 --- hose with nozzle

Another type of structural solution assembly with a capacity of 6 cubic meters per hour is designated for installation at the construction site. The operation of this assembly is fully mechanized, and it can deliver both simple solutions and complex solutions for bricklaying.

Soviet designers are engaged in work on new structural solution assemblies based on the principle of continuous action. These new installations will be of simpler design, lower cost, and greater operating convenience.

For the delivery of the solutions to the floor locations, new model solution pumps with capacities of 1, 2, or 3 cubic meters of solution per hour were introduced. These pumps are very compact: mounted on a wheel truck and weighing only 180 kilograms, they can be moved about by one man. The 1 cubic meter per hour pump operates at a working pressure of 10 atmospheres and pumps the solution throguh a 50-millimeter rubber hose to a distance of 40 meters.

The pumps are also capable of spraying the solutions upon the wall surfaces, for which purpose they are usually equipped with special nozzles, into which compressed air is fed for the purpose of accelerating the spray.

Recently the inventor A. E. Surzhanenko proposed the addition of alabaster to the structural solution handled by the pumps; since alabaster sets rapidly, it must not be fed into the pump. Comrade Surzhanenko fed alabaster into the nozzle through a special proportioning device in which the alabaster is mixed with the compressed air, the mixture being fed continuously to the nozzle.

The Soviet machine-building plants make complete kits of equipment for the mechanization of the wall-plastering operation. For a long time, attempts at the mechanization of the spreading of the covering layer of plaster were not successful. But in 1951 the difficulties were overcome, and the first plastering machines were built (Figure 15).

Figure 15. Machine for the spreading of plaster

Since the plastering machine must be held in one hand, it is very hard on the plasterer. Therefore, the design of this machine is being revised at present with a view to making it lighter. The new models are supposed to weigh no more than 1.8 kilograms.

Following close after plastering, painting is the next laborious job. A series of machines that will mechanize the process of painting are being manufactured by the Soviet machine-building industry (Figure 16)

Figure 16. Equipment assembly for painting with viscous paint compositions

For the preparation and preliminary treatment of the painting materials, the following equipment is built: paint grinders, hand- and mechanically-driven with capacities from 150 to 200 kilograms per hour; sieves for the straining of paint ingredients with a capacity of 200 to 300 kilograms per hour; mechanical mixers for the preparation of putty and priming paints, with a capacity of 80 to 100 kilograms per hour; etc.

The actual painting of the surfaces is also mechanized. For prime coating and water-base painting, electrically-operated painting booths weighing 17 kilograms are built. These painting installations insure the work of two painting tackles and produce 400 square meters of painted surface per hour.

The mass production of universal head paint guns, equipped with special heads for the spreading of the filler coat, has been mastered.

The experimental model paint spray gun, the use of which will reduce the paint losses 8 to 10 times as a result of the reduction in the formation of fog, has passed successfully through all the tests. In addition to paint economy, this spray gun makes it possible for the painters to work without respirator masks.

Several types of compressors are built to provide compressed air for the automatic plastering and painting.

The smallest of these is a portable compressor weighing 18 kilograms and producing 0.1 cubic meters of compressed air per minute. It is used in high-grade surface finishing, on so-called "al'freic" jobs.

Two other types of portable compressors with capacities of 0.25 and 0.5 cubic meters per minute are used for general painting and plastering. The air pressure delivered by these compressors is four atmospheres, which is fully adequate for the operation of the finishing machines.

The finishing of parquet and tile floors, too, belongs in the category of laborious jobs.

The process of finishing parquet floors is now fully mechanized. Special parquet floor planers with capacities of 50 square meters per hour and parquet polishers with capacities of 25 to 30 square meters per hour are in use.

Special polishing machines are used for finishing tile floors. They have a capacity of 10 to 15 square meters of floor surface per hour.

An entire series of finishing and auxiliary jobs in construction which were previously performed by hand are now done by means of electrically- and pneumatically-driven tools.

There are chain and circular saws, planes, slotters, and drills for woodworking jobs. There are electrically-operated riveting hammers, wrenches, stud tighteners, drills, peening hammers for welded seams, machines for the grinding and polishing of metal surfaces, shears, etc.

The above-enumerated tools are now driven by high-frequency electric motors; this considerably increases their capacities witha simultaneous reduction in weight.

Continuous efforts are made to expand the nomenclature of electric tools and to introduce new models.

Not long ago, a universal electrically-driven tool submitted by Kulikov, a pattern maker at the Leningrad "Elektroinstrument" Plant, was successfully tested. This universal tool, through the insertion of various working units, is capable of performing a series of operations in woodworking.

The machinery described in this booklet is only a partial representation of the wide range of machinery covered by the construction machine-building industry.

The projects for the erection of remarkable structures in our land are equipped with hundreds of types and sizes of construction machinery and devices which provide for the complex mechanization of our ever-expanding building industry.

The successes in construction are the successes of the builders, scientific personnel, and the workers engaged in the field of construction machine building, among which the ranks of the Stalin prize winners are increasing from year to year.

The progress already attained in the mechanization of construction inspires confidence in the ability of the machine builders to tackle successfully the ever present problem of further improving construction machinery and equipment, which will bring greater ease to the labors of the builders, will provide for still higher quality and workmanship, and will considerably advance the dates for the completion of the great Stalin construction projects of Communism.

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